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THE IDENTIFICATION OF ELASTIC PROPERTIES OF COMPOSITE MATERIALS BY MODAL ANALYSIS APPROACH

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Summary: The identification of elastic properties of composite material is of great significance but also a challenge. The traditional mechanical tests show their limitations in the identification. An identification method based on the correlation between the measured frequencies and calculated frequencies is proposed to overcome these limitations.
This method contains four modules: the mechanical test, the vibration test, a finite element model and the identification. The mechanical tests (tensile and torsion test) are carried out and provide initial values for the finite element model whose outputs are calculated frequencies and mode shapes. A discrete Kirchhoff plate element is used in the finite element model. This finite element is validated by comparing calculated frequencies with analytical solution before application. Meanwhile, measured resonance frequencies and mode shapes are obtained by vibration test whose main instruments are shaker and laser vibrometer. By observing both the measured and calculated modes shapes, the modes can be divided into several groups. Each group has its dominating parameter, which has been verified by sensitivity analysis of parameters. Within one group, the dominating parameter is updated every iteration in order to minimize the difference between the calculated frequencies and the measured frequencies of that group. At the same time, the mode shapes are also observed to guarantee that the calculated mode matches the measured mode. An optimized result is obtained when the difference of frequencies is small enough.
This method has been applied to two types of composite plates: unstitched plate and stitched plate. Both plates are made of woven 5 harness satin carbon fiber fabric and epoxy resin and molded by Vacuum Assisted Resin Infusion Molding technique. The difference is that several zones of the dry fabric of the stitched plate have been stitched by a robot using 'one-side stitching'. The identification of the stitched plate focuses on the stitched zones. Based on the correlation experiment-calculation of more than 20 modes, the Young's modulus and torsion modulus of both the unstitched plate and the stitches are successfully identified. The Young's modulus of the unstitched plate and that along length direction of the stitch are close to the result of mechanical test.
This method exhibits several advantages in the identification of elastic properties of composite materials: the elastic properties along different directions can be obtained simultaneously; a more satisfied level of homogenization is achieved since the whole structure is taken into consideration; the identified result contains more information of dynamic behavior of structure.